PATENT ABSTRACTS OF JAPAN

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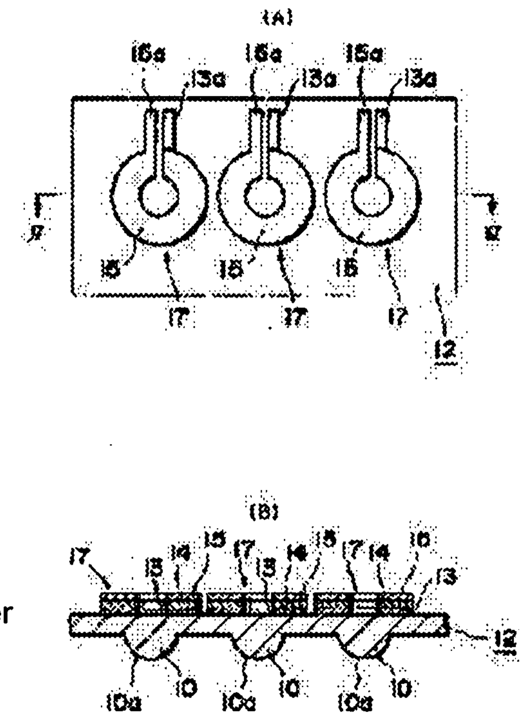
(54) MICROOPTICAL ELEMENT, FUNCTION ELEMENT UNIT AND THEIR PRODUCTION

(57)Abstract:

PROBLEM TO BE SOLVED: To provide microoptical elements which may be adjusted in focus.

SOLUTION: An optical substrate 12 is formed of polyimide. Plural convex lenses 10 having convex surfaces 10a are two-dimensionally arrayed and formed on one surface of this substrate 12. The rear surface of the optical substrate 12 is a flat surface and on which PZT actuators 17 comprising lower layer metallic films 13, PZT thin films 14 and upper layer metallic films 15 are formed at the points corresponding to the circumferences of the convex surfaces 10 of the convex lenses 10. When voltage is impressed between the lower layer metallic films 13 and the upper layer metallic films 15, distortion arises in the PZT thin films 14. The radius of curvature of the convex lenses 10 is changed by this distortion, by which the focal length or depth of focus of the convex lenses 10 is changed.



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CLAIMS

[Claim(s)]
[Claim 1] The micro optical element equipped with an optical element and a stress generating member with an optical functional side by which the above-mentioned stress generating member is formed in the perimeter of the above-mentioned optical element.
[Claim 2] The manufacture approach of an optical element of forming on a substrate the crevice equivalent to the optical functional side of the optical element which should be produced, forming polyimide on the above-mentioned substrate so that the above-mentioned crevice may be filled, and separating from a substrate the part of the above-mentioned polyimide which filled the above-mentioned crevice at least.
[Claim 3] The creation approach of the minute spacial-configuration object which approaches the above-mentioned object at the substrate with which the object which should be made to transform was supported deformable, prepares the movable electrode supported by the member in which elastic deformation is possible, is made to counter with the above-mentioned movable electrode, prepares a fixed electrode, impresses an electrical potential difference between the above-mentioned movable electrode and the above-mentioned fixed electrode, and makes transform the above-mentioned object with the above-mentioned movable electrode which this displaces.
[Claim 4] The creation approach of the functional-device unit which prepares a functional device in a substrate by the deformable leg, approaches the leg, prepares the movable electrode supported by the member in which elastic deformation is possible, is made to counter with the above-mentioned movable electrode, prepares a fixed electrode, impresses an electrical potential difference between the above-mentioned movable electrode and the above-mentioned fixed electrode, and is made to deform the above-mentioned leg with the above-mentioned movable electrode which this displaces.
[Claim 5] The creation approach of the functional-device unit according to claim 4 which heats and stiffens the above-mentioned leg after forming the above-mentioned leg with a thermosetting ingredient and deforming the above-mentioned leg.
[Claim 6] It is the functional-device unit in which the movable electrode for being made to deform the above-mentioned leg and making the above-mentioned leg deform is prepared [support / a functional device / by the deformable leg / by the substrate] by approaching the above-mentioned leg.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001] This invention relates to a micro optical element, functional-device units, and these manufacture approaches.
[0002]
[Description of the Prior Art] Many optical instruments have the focus device in which focusing is performed. Focusing is performed when a focus device moves a lens along with a frame including the frame supported for a lens, enabling free migration. There is also a focus device in which two or more lenses are built into a frame, and are constituted. A certain amount of magnitude is inevitably required of a frame and the optical equipment which includes a focus device depending on the case since two or more lenses are required, and a miniaturization is difficult.
[0003] In recent years, the miniaturization of electronic equipment is attained using the micro-machining technique. There is a miniaturization by configurations, such as an electronic device, as one of the approach of the. This forms on a substrate the optical element formed on the substrate, an electronic device, electronic parts, etc. in three dimension using a micro manipulator. Compared with the electronic equipment by which the electronic device etc. has been arranged two-dimensional, much more promotion of a miniaturization can be aimed at by what has been arranged in three dimension.
[0004] However, actuation of a micro manipulator is very difficult and it is necessary to perform it carefully over many hours. Since further two or more electronic devices etc. cannot be made into the three-dimensional structure at coincidence, there is a fault that mass-production nature is missing.
[0005] Although there is also a method of joining two or more semi-conductor wafers in which the electronic device etc. was formed, as the approach of a miniaturization of electronic equipment, and integrating, since virtual junction temperature is high (about 1000 degrees), this approach is not employable as the electronic equipment incorporating the electronic device which cannot bear an elevated temperature.
[0006]
[Description of the Invention] This invention offers a micro optical element with a focus control device.
[0007] This invention offers the approach of assembling a functional device in three dimension easily again.
[0008] The micro optical element by this invention is equipped with an optical element and a stress generating member with an optical functional side, and the above-mentioned stress generating member is formed in the perimeter of the above-mentioned optical element.
[0009] There is a lens as an example of the above-mentioned optical element. A lens has the shape of the shape of the spherical surface, and the aspheric surface, convex, and a concave optical functional side including a spherical lens, an aspheric lens, a convex lens, a concave lens, etc., respectively. There are a polarizing element, a deviation component, a reflector, etc. as other examples of the above-mentioned optical element.
[0010] The above-mentioned stress generating member is formed with piezoelectric material, an electrostriction ingredient, or a magnetostriction ingredient.

[0011] The above-mentioned stress generating member can be formed in the part corresponding to the perimeter of the above-mentioned optical functional side in the perimeter of the optical functional side of the above-mentioned optical element, or its opposite side.
[0012] Preferably, a part of perimeter of the above-mentioned optical functional side is supported by the supporter. By deforming a supporter, arrangement of an optical element is changeable.
[0013] 1 operative condition, the above-mentioned optical element is set like, and it forms on a substrate the crevice equivalent to the optical functional side of the optical element which should be produced, it forms polyimide on a substrate so that this crevice may be filled, and it is manufactured by separating the part of the above-mentioned polyimide which filled the crevice at least from a substrate.
[0014] A sacrifice layer may be formed on the substrate which has a crevice, and the above-mentioned polyimide film may be formed on this sacrifice layer. In a sacrifice layer, it is SiO2. Metallic materials, such as aluminum, are used. By removing only a sacrifice layer by etching, the polyimide with which the optical element was formed can be easily exfoliated from a substrate.
[0015] When the above-mentioned stress generating member is piezoelectric material, distortion arises in a stress generating member by impression of an electrical potential difference. The configuration of the optical functional side of an optical element changes with these distortion. In the case of an electrostriction ingredient and a magnetostriction ingredient, the configuration of an optical functional side changes with work of electric field and a field similarly, respectively. Thus, without [without it moves an optical element (lens), or] using two or more optical elements, a focal distance or the depth of focus can be changed, and a miniaturization becomes possible. In the optical instrument which has a group lens for a focus, the number of the lenses which constitute a group lens can be decreased, and much more miniaturization of an optical instrument is attained.
[0016] The creation approach of the minute spacial-configuration object by this invention approaches the above-mentioned object, it prepares the movable electrode supported by the member in which elastic deformation is possible, make it counter with the above-mentioned movable electrode, it prepares a fixed electrode, impresses an electrical potential difference between the above-mentioned movable electrode and the above-mentioned fixed electrode, and makes transform the above-mentioned object into the substrate with which the object which should be made to transform was supported deformable with the above-mentioned movable electrode which this displaces.
[0017] According to this invention, the variation rate of the movable electrode which happens by impressing an electrical potential difference between the movable electrode supported by the member in which elastic deformation is possible, and the fixed electrode which countered the movable electrode and was prepared is used for deformation of the above-mentioned object. A movable electrode and a fixed electrode may be prepared on both sides of an object. In this case, a movable electrode will push an object. It can also consider as the arrangement which sandwiches a movable electrode with an object and a fixed electrode. In this case, since a movable electrode will pull an object, a movable electrode and an object are combined with a certain means.
[0018] A fixed electrode is prepared in a substrate other than the substrate in which an object and a movable electrode are prepared preferably, and where both these substrates are joined, an electrical potential difference is impressed between two electrodes. The substrate with which an object and a movable electrode are prepared is a semi-conductor substrate preferably.
[0019] Since an object can be made to transform only by impressing an electrical potential difference between two electrodes according to this invention, that actuation is comparatively easy. The degree of deformation of an object can be set as arbitration by controlling the electrical potential difference to impress, and the object which deformed can be held in the condition of having deformed when required.
[0020] The creation approach of the functional-device unit by this invention uses the creation approach of the spacial-configuration object mentioned above, prepares a functional device in a substrate by the deformable leg, approaches the leg, prepares the movable electrode supported by the member in which elastic deformation is possible, make it counter with the above-mentioned movable electrode, it prepares a fixed electrode, impresses an electrical potential difference between the above-mentioned movable electrode and the above-mentioned fixed electrode, and makes transform the above-mentioned object

with the above-mentioned movable electrode which this displaces.
[0021] A functional device contains optical elements, such as a light emitting device, a photo detector, and a lens, and the component preferably used for a micro optical element, a micro electronic device, other optical instruments, and electronic equipment.
[0022] Since according to this invention a functional device can be brought to the posture of arbitration only by impressing an electrical potential difference between a movable electrode and a fixed electrode and batch processing becomes possible, the functional-device unit (for example, micro optical unit) by which the functional device has been arranged in three dimensions can be manufactured in large quantities at once. Moreover, since the lamination technique of semi-conductor wafers is not used, it is not necessary to perform high temperature processing. In the functional-device unit manufactured by this invention, since the functional device is arranged in three dimensions the upper part, a lower part, or inside the substrate (when there is a hole), the miniaturization of the whole unit can be attained.
[0023] That is, the functional-device unit by this invention is supported by the substrate by the leg with a deformable functional device, the movable electrode for being made to deform and making the leg deform approaches the above-mentioned leg, and the leg is prepared.
[0024] Preferably, the above-mentioned leg is formed with a thermosetting ingredient, and after deforming the above-mentioned leg, the above-mentioned leg is heated and stiffened.
[0025] The posture which the functional device displaced can be held by making it harden, where the leg is deformed. Polish recon is preferably used for the above-mentioned leg. Polish recon has the property which will be hardened if energized and heated.
[0026]
[Example]
(1) Micro optical element drawing 1 is the sectional view showing some optical substrates with the lens array produced using polyimide.
[0027] The optical substrate 12 is a tabular polyimide substrate, and two or more convex lenses 10 are formed in the whole surface, and it is arranged two-dimensional. Convex surface 10a of a convex lens 10 is a smooth surface. A lens array is constituted by two or more of these convex lenses 10. The convex lens 10 of a simple substance can be formed by dividing the optical substrate 12 by dicing. A convex lens 10 is used in order to condense the light collimated or it emitted or to collimate the light to emit.
[0028] Drawing 2 shows the making process of the optical substrate 12 shown in drawing 1 .
[0029] A substrate 20 is prepared (drawing 2 (A)). Silicon is used for the ingredient of a substrate 20. Micro processing is possible for silicon by the micro-machining technique.
[0030] Crevice 20a which has a configuration corresponding to the configuration of convex surface 10a of the convex lens 10 which should be formed in the whole surface of a silicon substrate 20 is formed by isotropic etching (drawing 2 (B)). On a silicon substrate 20, two or more crevice 20a arranged two-dimensional is formed. By forming two or more crevice 20a on a silicon substrate 20, two or more convex lenses 10 are producible at once.
[0031] It is SiO_2 on a silicon substrate 20. The sacrifice layer 11 is formed by thermal oxidation or deposition (drawing 2 (C)). SiO_2 Crevice 11a with a smooth surface is formed in the location which is equivalent to crevice 20a also on the front face of the sacrifice layer 11. SiO_2 The sacrifice layer 11 is used in order to make easy separation from the silicon substrate 20 of the optical substrate 12 to produce. Metals, such as aluminum, may be used as a sacrifice layer.
[0032] SiO_2 Polyimide 12 is applied and stiffened so that crevice 11a may be buried from on the sacrifice layer 11 (drawing 2 (D)).
[0033] It is SiO_2 by etching after hardening of polyimide 12. The sacrifice layer 11 is removed and the optical substrate 12 is separated from a silicon substrate 20. The part buried with crevice 11a serves as a convex lens 10, and the optical substrate 12 with which two or more convex lenses 10 were arranged two-dimensional is completed (drawing 1).
[0034] Drawing 2 (B) In setting and forming crevice 20a, according to the depth, magnitude, etc. cutting off a silicon substrate 20, the engine performance (radius of curvature, a focal distance, depth of focus, etc.) of the lens to produce can be changed.

[0035] Drawing 3 is the sectional view showing some optical substrates of other structures produced using polyimide.
[0036] In optical substrate 12A, concaved surface 10b is formed in the opposite side by the smooth surface corresponding to convex surface 10a of convex lens 10A.
[0037] Concaved surface 10b of convex lens 10A is formed by forcing La Stampa with the convex mold face equivalent to concaved surface 10b, or shaving off the polyimide after hardening by etching, before polyimide hardens.
[0038] It cannot be overemphasized that it is good also considering concaved surface 10b of the configuration of convex surface 10a of a convex lens 10 and convex lens 10A and convex lens 10A as other configurations.
[0039] Drawing 4 shows the structure of the optical substrate equipped with the PZT (PZT) actuator, and is (A). The top view and (B) are IV-IV of (A). It is a sectional view so at a line. Drawing 4 (B) It sets, and in order for a plot to reach for convenience and to make it intelligible, the thickness of each configuration member of a PZT actuator also emphasizes a twist, and is actually drawn. This is the same also in other sectional views mentioned later. The same sign is given to the same thing as what is shown in drawing 1 , and duplication explanation is omitted.
[0040] In the flat side (the field in which convex surface 10a was formed, and field of the opposite side) of the optical substrate 12, the lower layer metal membrane 13, the PZT (PZT) thin film 14, and the upper metal membrane 15 put the PZT actuator 17 on this sequence, and it is formed. The PZT actuator 17 has the annular part formed annularly and the two straight-lines-like part formed in the shape of a straight line. The annular part is formed in the part corresponding to the periphery of convex surface 10a of a convex lens 10 in the flat side of the optical substrate 12. A part of annular part was separated and the straight-line-like part is prolonged in the method of outside from the both ends.
[0041] The two straight-lines-like part of the PZT actuator 17 is used as a drive terminal (external connection terminal) of the PZT actuator 17. The lower layer metal membranes 13, the PZT thin films 14, and all the upper metal membranes 15 (the upper metal membrane 15 of a straight-line-like part is shown as terminal 15a) are formed in one side among two straight-lines-like parts. Only the lower layer metal membrane 13 (the lower layer metal membrane 13 of a straight-line-like part is shown as terminal 13a) is formed in the straight-line-like part of another side. If it lets these terminals 13a and 15a pass and an electrical potential difference is applied between the lower layer metal membrane 13 and the upper metal membrane 15, distortion (stress) will occur inside these metal membranes 13 and the PZT thin film 14 pinched among 15. Distortion and its radius of curvature change [a convex lens 10] with these. If a convex lens 10 is distorted and the radius of curvature changes, the focal distance or the depth of focus of a convex lens 10 will change.
[0042] By what (the electrical potential difference applied to the PZT actuator 17 is controlled) distortion generated in the PZT thin film 14 is controlled for, the focal distance or the depth of focus of a convex lens 10 can be adjusted, without [without it uses two or more lenses, or] moving the lens itself. In the optical instrument which has a group lens for a focus, since the number of the lenses which constitute a group lens can be decreased, the miniaturization of an optical instrument is attained. Moreover, even when the engine performance (radius of curvature, a focal distance, depth of focus, etc.) of a lens becomes the value designed with aging of polyimide, or heating at the time of mounting, and a different value, after mounting a lens in an optical instrument, the fine tuning can be aimed at. For this reason, in actual use of an optical instrument, the lens engine performance of the same request as what was designed can be obtained. Although the lens array is shown by drawing 4 , it cannot be overemphasized that the above-mentioned thing is applied also about the lens of a simple substance.
[0043] Drawing 5 shows the structure which attached the supporter to a convex lens with the PZT actuator shown in drawing 4 , and is (A). The top view and (B) are V-V of (A). It is a sectional view so at a line. In these drawings, although the condition that three lenses of a simple substance were arranged is shown, this depends on signs that three lenses were produced to coincidence in explanation of the making process having been shown. Drawing 6 and drawing 7 show the making process of the convex lens which attached the supporter shown in drawing 5 . It is the top view of (B1) shown in left-hand side

in drawing 6 (A1), and (C1) (D1) an optical substrate, and they are (B-2) shown in right-hand side (A2), and (C2) (D2) the corresponding sectional view of a top view. Similarly, it is the top view of an optical substrate, and it is shown in right-hand side (A2), and (B-2) is [in / it is shown in left-hand side (B1) (A1) / drawing 7] the sectional view of a corresponding top view.
[0044] Drawing 2 (A) - (C) SiO2 which forms crevice 20a of the configuration which is equivalent to the convex front face of the convex lens which should be produced on a silicon substrate 20 like the shown process, and has crevice 11a on it The sacrifice layer 11 is built (drawing 6 (A1), (A2)). Then, SiO2 Polish recon 16A is deposited so that crevice 11a of the sacrifice layer 11 may be buried (drawing 6 (B1), (B-2)). Then, it leaves the supporter 16 of polish recon which consists of an annular part which lacked the part, and a straight-line-like part extended from the both ends of an annular part to the method of outside, and all of polish recon 16A of other fields are removed (drawing 6 (C1), (C2)). The annular part of a supporter 16 is in the location equivalent to the periphery of Crevices 20a and 11a, and supports the convex lens 10 which should be formed in a degree.
[0045] Crevice 11a is buried and it is SiO2. Polyimide 12 is applied and stiffened so that the sacrifice layer 11 and a supporter 16 may be covered (drawing 6 (D1), (D2)). After hardening of polyimide 12, and in crevice 11a, it leaves the polyimide on the interior of the annular part of a supporter 16, its top face (except for a periphery edge), and the straight-line-like part of a supporter 16, and all the polyimide 12 of other parts is removed (drawing 7 (A1), (A2)). [0046] from which the remaining polyimide serves as a convex lens 10 The PZT actuator 17 which consists of the lower layer metal membrane 13, a PZT thin film 14, and the upper metal membrane 15 is formed on the flat side of a convex lens 10 (drawing 7 (B1), (B-2)).
[0047] SiO2 The sacrifice layer 11 is removed by etching. SiO2 It has the part of the polyimide embedded at crevice 11a of the sacrifice layer 11 as a lens part, and the convex lens 10 with which the annular part of a supporter 16 faced across the perimeter is completed. It becomes the form where the PZT actuator 17 was formed through the layer of polyimide on this supporter 16 (drawing 5).
[0048] SiO2 If the sacrifice layer 11 is not removed, two or more convex lenses 10 are maintained at the condition of having been arranged on the silicon substrate 20, and constitute a lens array. This configuration is shown in drawing 8 . Only the part corresponding to convex surface 10a of a convex lens 10 in a silicon substrate 20 is shaved [inferior surface of tongue / the] by etching. Sign 20A shows the hole shaved off by etching. Light will pass along this hole 20A. A silicon substrate 20 and SiO2 While convex surface 10a of a convex lens 10 is protected by the sacrifice layer 11, the handling in conveyance etc. becomes easy.
[0049] (2) Explain the creation approach of a minute spacial configuration object in advance of explanation of the micro optical unit (micro optical spacial configuration object) using the micro optical element in which the minute spacial configuration object carried out the creation approach ****.
[0050] Drawing 9 is the perspective view showing a minute spacial configuration object and the auxiliary structure used for the process which makes the functional device in a minute spacial configuration object stand up. Drawing 10 is X-X of drawing 9 . It is a sectional view so at a line. A minute spacial configuration object points out that by which the functional device with a certain physical function represented with a lens, a light emitting device, a photo detector, etc. was prepared on the substrate by the leg here. Although a functional device and the leg are in the posture which went to sleep at first, they are made to stand up so that it may explain below using the auxiliary structure. In this specification, although it is in the thing in the posture into which the functional device went to sleep, and the posture which stood up, both shall be called minute spacial configuration object for convenience.
[0051] In the minute spacial configuration object 30 shown in drawing 9 and drawing 10, a functional device 44 and the leg 43 are in the posture which went to sleep. The minute spacial configuration object 30 contains the silicon substrate 32 with conductivity. In the center section of this silicon substrate 32, hole 32A is formed in the vertical direction. The part of the silicon substrate 32 around this hole 32A is called frame section 33. A movable electrode 34 is formed in the center of the upper part of hole 32A, and this movable electrode 34 is combined with the upper part of the frame section 33 in one with the bar 35 extended in both directions from that 1 side. These frame sections 33, a movable electrode 34,

and a bar 35 can be formed by etching a silicon substrate 32 with high precision.
[0052] The bar 35 is formed quite thinly. The movable electrode 34 supported by the upper part of the frame section 33 with the bar 35 is also built thinly. Elastic deformation (twist to mention later) is possible for the bar 35 formed thinly.
[0053] On the frame section 33 of a silicon substrate 32, the insulator layer 41 of two outline squares opens spacing, and is formed, and the external connection terminal 42 of the same form as an insulator layer 41 is formed on this two insulator layer 41, respectively. It is formed in [the external connection terminal 42 and the leg 43] one, and the leg 43 is jutted out from the external connection terminal 42 to the upper part for a point of a movable electrode 34, and each other is connected there. Few gaps are between the leg 43 and a movable electrode 34. The external connection terminal 42 and the leg 43 are built by polish recon (electric resistor), and a current is passed by the leg 43 through the external connection terminal 42 so that it may mention later. a functional device 44 -- a movable electrode 34 -- in the location right above, it is mostly attached in a part for the point of the leg 43.
[0054] The auxiliary structure 31 is formed with insulating ingredients, such as glass, and has the magnitude corresponding to a silicon substrate 32. The square pole-like supporter 37 is formed in the four corners of the side which counters the silicon substrate 32 of the auxiliary structure 31. The part except the supporter 37 of the auxiliary structure 31 is built thinly.
[0055] In the part with which the auxiliary structure 31 was built thinly, the fixed electrode 46 which has the almost same magnitude as a movable electrode 34 and a configuration in the location which counters a movable electrode 34 is formed. Terminal 46a is extended from some fixed electrodes 46 to the edge of the auxiliary structure 31. Terminal 46a is used in order to impress an electrical potential difference to a fixed electrode 46 so that it may explain below.
[0056] Drawing 11 (A), (B), and (C) The process which makes the functional device in a minute spacial configuration object stand up is shown.
[0057] After laying the inferior surface of tongue of the supporter 37 of the auxiliary structure 31 on top of the frame section 33 of a silicon substrate 32 and fixing, an electrical potential difference is applied between a fixed electrode 46 and a movable electrode 34 through terminal 46a and a silicon substrate 32. Then, electrostatic force (electrostatic attraction) occurs between a fixed electrode 46 and a movable electrode 34, and the amount of [of a movable electrode 34] (the 1 side currently supported with the bar 35 is the opposite side) point can draw near to a fixed electrode 46. Since the 1 side is supported by the bar 35 in which a movable electrode 34 has possible elastic deformation (twist), the amount of [of a movable electrode 34] point stands up (drawing 11 (A)).
[0058] Since it is located above a movable electrode 34 by the amount of [of the leg 43] point, if the amount of [of a movable electrode 34] point can draw near to a fixed electrode 46, the leg 43 will be pushed up up. The leg 43 formed of the polish recon which is rich in resiliency has been shaved coming to smooth. The functional device 44 prepared at the tip of the leg 43 stands up by curve going up of the leg 43 (drawing 11 (B)).
[0059] Where an electrical potential difference is applied between a fixed electrode 46 and a movable electrode 34, a current is passed from two external connection terminals 42 on the frame section 33 to the leg 43. The polish recon which constitutes the leg 43 is heated by energization, and is hardened. When the leg 43 hardens, a functional device 44 is fixed with the posture which stood up. If impression of the electrical potential difference to a fixed electrode 46 and a movable electrode 34 is stopped, a movable electrode 34 will return to the original location (drawing 11 (C)).
[0060] Drawing 12 is the perspective view showing other minute spacial configuration objects and auxiliary structures of structure. Drawing 13 is XIII-XIII of drawing 12. It is a sectional view so at a line. The point that the glue line 47 by which hole 47A was opened between a movable electrode 34 and the leg 43 as compared with the minute spacial configuration object 30 which shows this minute spacial configuration object 30A to drawing 10 and drawing 11 is formed differs from the point that hole 34A is opened in the movable electrode 34. Other structures are the same as what is shown in drawing 10 and drawing 11. Moreover, the auxiliary structure 31 is arranged under the minute spacial configuration object 30A.

[0061] In minute spacial configuration object 30A, the leg 43 has pasted the movable electrode 34 by the glue line 47 prepared between a movable electrode 34 and the leg 43. Moreover, hole 34A opened in the movable electrode 34 is in the location inserted into two feet of the leg 43. Hole 47A of a glue line 47 is opened in the location corresponding to hole 34A.
[0062] the auxiliary structure 31 -- the fixed electrode 46 -- the lower part of hole 32A -- it arranges under the silicon substrate 32, and the inferior surface of tongue of the supporter 37 of the auxiliary structure 31 is laid on top of the inferior surface of tongue of the frame section 33 of a silicon substrate 32, and it fixes so that it may come in the center mostly. An electrical potential difference is applied between a fixed electrode 46 and a movable electrode 34 through terminal 46a and a silicon substrate 32. By the electrostatic force (electrostatic attraction) committed between a fixed electrode 46 and a movable electrode 34, a movable electrode 34 is the other side caudad. Since the movable electrode 34 is pasted by the glue line 47, the leg 43 also breaks caudad and the leg 43 turns at it. The functional device 44 attached in the leg 43 enters in hole 32A of a silicon substrate 32, where a handstand is done.
[0063] The leg 43 is made to harden the polish recon which constitutes a sink and the leg 43 for a current, where an electrical potential difference is applied between a fixed electrode 46 and a movable electrode 34. Impression of the electrical potential difference to a fixed electrode 46 and a movable electrode 34 is returned at the end, and a stop and a movable electrode 34 are returned to the original location. The leg 43 and moving part 34 maintain the posture stored in hole 32A.
[0064] Although stated later in detail, when a functional device 44 is a light emitting device, outgoing radiation of the light is carried out through between Holes 47A and 31A and the legs 43. When a functional device 44 is a photo detector, the light passing through between Holes 47A and 31A and the legs 43 can be received.
[0065] (3) Explain the micro optical unit created using the creation approach of the minute spacial configuration object which carried out micro optical unit ****.
[0066] Drawing 14 is the sectional view of a micro optical unit (micro optical spacial configuration object) where the convex lens with which the PZT actuator was formed was prepared on the substrate by the leg. Since the structure of the micro optical unit 60 shown in drawing 14 becomes clear by explaining the making process, with reference to drawing 20, the making process is explained from drawing 15. Drawing 17 is shown in left-hand side from drawing 15 (A1), and (B1) (C1) it is the top view of the making process of a micro optical unit. It is the sectional view of the (B-2) and (C2) the corresponding top view which are shown in right-hand side (A2). the same -- drawing 18 -- setting -- left-hand side -- being shown (A1) -- the top view of the making process of a micro optical unit -- it is -- right-hand side -- being shown (A2) -- XVIII-XVIII of (A1) It is the sectional view which meets a line.
[0067] A silicon substrate 32 is prepared and Crevices 32a and 32b are formed in two places of the top face by etching. Crevice 32a is formed so that it may leave the part which should become a movable electrode 34 to the top face of a silicon substrate 32, and so that it may leave the part which should become a bar 35 in Crevices 32a and 32b (drawing 15 (A1), (B1)).
[0068] It is SiO2 so that crevice 32a and crevice 32b may be completely covered in the center section of the top face of a silicon substrate 32. The sacrifice layer 51 is formed by thermal oxidation or deposition. The periphery of crevice 32a and crevice 32b is SiO2. It is buried by the sacrifice layer and is SiO2. Crevice 51b remains in the location where crevice 51a is equivalent to the location which is equivalent to the center section of crevice 32a on the front face of the sacrifice layer 51 in the center section of crevice 32b, respectively (drawing 15 (B1) and (B-2)).
[0069] Furthermore, it is SiO2. The polish recon 52 is deposited so that Crevices 51a and 51b may be filled on the sacrifice layer 51 (drawing 15 (C1), (C2)).
[0070] The polish recon 52 is circularly shaved off by isotropic etching in the location equivalent to crevice 51a, and crevice 52a with a smooth surface is formed (drawing 16 (A1), (A2)).
[0071] It is SiO2 so that the polish recon 52 may be covered. The sacrifice layer 53 is built (drawing 16 (B1), (B-2)). SiO2 The sacrifice layer 53 is SiO2. The circumferential side face of the sacrifice layer 51 and the polish recon 52 is also a wrap. SiO2 Crevice 53a which has a smooth surface in the location equivalent to crevice 52a remains in the front face of the sacrifice layer 53. The convex lens produced

from now on has the convex front face of the configuration equivalent to crevice 53a.
[0072] SiO2 The polish recon supporters 54 are formed over a silicon substrate 32 top from on the sacrifice layer 53 (drawing 16 (C1), (C2)). These polish recon supporters 54 are formed of patterning of polish recon, and deposition, and consist of annular partial 54A which the perimeter of crevice 53a was enclosed and lacked the part, and leg part 54B extended from the both ends of annular partial 54A. Leg part 54B is extended even on the substrate 32. 54C shows the part prepared on this substrate 32. Partial 54C is prepared through the insulating layer 58 on the substrate 32. While the polish recon supporters 54 support the perimeter of the convex lens produced from now on, it is used in order to maintain the posture of a convex lens (it is heated by passing a current and hardens). Partial 54C formed on the substrate 32 is used also as a terminal used for passing a current.
[0073] Crevice 53a is buried and the polyimide 55 which meets inside the polish recon supporters 54 and is extended is formed by patterning and deposition (A2). (drawing 17 (A1)) The point of polyimide 55 is further formed on mileage and a substrate 32 from the polish recon supporters 54 at the method of outside. The part of the polyimide 55 which buries crevice 53a is set to convex lens 55A. 55C shows the polyimide part formed on the substrate 32 by 55B in the polyimide part formed on the polish recon supporters' 54 leg 54B.
[0074] The PZT actuator 17 which consists of the lower layer metal membrane 13, a PZT thin film 14, and the upper metal membrane 15 is formed on the periphery of convex lens 55A, and polyimide partial 55B and 55C (drawing 17 (B1), (B-2)). On [one] two polyimide parts 55B and 55C, the laminating only of the lower layer metal membrane 13 is carried out like the structure shown in drawing 4 , drawing 5 , and drawing 8 .
[0075] Two etching is performed after the above process. The first etching is the inferior surface of tongue to SiO2 about the center section of the silicon substrate 32. It shaves off to the location of the sacrifice layer 51 bottom (drawing 17 (C1), (C2)). Crevice 32B is formed in a silicon substrate 32. This crevice 32B is formed in the part of a rectangle including Crevices 32a and 32b.
[0076] SiO2 exposed by the 1st etching 2nd [further] etching is performed from the inferior surface of tongue of the sacrifice layer 51, a movable electrode 34, and a bar 35, and it is SiO2. The sacrifice layer 51, the polish recon 52, and SiO2 The sacrifice layer 53 is removed (A2). (drawing 18 (A1)) In a silicon substrate 32, hole 32A which leads in the vertical direction opens. The micro optical unit (micro optical spacial configuration object) 60 by which convex lens 55A was supported by the substrate 32 above hole 32A by the polish recon supporters 54, and the PZT actuator 17 was formed on the polish recon supporters 54 is completed.
[0077] As shown in drawing 19, the glass substrate 31 with which the fixed electrode 46 was formed is placed on a silicon substrate 32, the inferior surface of tongue of the supporter 37 of a glass substrate 31 is piled up on the frame section 33 of a silicon substrate 32, and anode plate junction is carried out.
[0078] If an electrical potential difference is impressed to a fixed electrode 46 and a movable electrode 34 as shown in drawing 20, the amount of [of a movable electrode 34] point can draw near to a fixed electrode 46, and the polish recon supporters 54 and convex lens 55A will stand up on a silicon substrate 32. If a current is passed from partial 54C of the polish recon on a substrate 32 to the polish recon supporters 54 in this condition, the polish recon supporters 54 will be heated and will harden. Convex lens 55A is fixed with the posture which stood up on the silicon substrate 32 by the polish recon supporters 54.
[0079] Application drawing 21 is the sectional view of an optical switching unit where the micro optical unit equipped with the convex lens with the PZT actuator shown in drawing 14 and the micro optical unit equipped with the photo detector were formed in one using the same substrate. The same sign is given to the same thing as what is shown in drawing 14, and duplication explanation is avoided.
[0080] As for the optical switching unit 80, two holes 32A and 32C are made in this substrate 32 including the substrate 32. It is prepared above one hole 32A with the posture into which convex lens 55A supported by the polish recon supporters 54 stood up. That is, by passing a current, where an electrical potential difference is impressed between movable electrode 34A and fixed electrode 46A, the polish recon supporters 54 are made to stand up, and are fixed to the posture.

[0081] On the other hand, movable electrode 34B is formed above hole 32C, and the photo detector 71 is formed in the substrate 32 by the leg 72 right above [this]. Fixed electrode 46B is prepared in the auxiliary structure 31 [above movable electrode 34B]. Standing up and proneness of a photo detector 71 are controlled by the electrical potential difference impressed between movable electrode 34B and fixed electrode 46B.
[0082] If an electrical potential difference is impressed between fixed electrode 46B and movable electrode 34B, movable electrode 34B can be drawn near to fixed electrode 46B, and a photo detector 71 will stand up on a silicon substrate 32. The light by which outgoing radiation was carried out from the light emitting device (illustration abbreviation) is condensed or collimated by convex lens 55A, and carries out incidence to a photo detector 71. At this time, an optical switch is ON.
[0083] If impression of the electrical potential difference of a between [fixed electrode 46B and movable electrode 34B] is stopped, movable electrode 34B will return to the posture into which it returned to the original location and the photo detector 71 also went to sleep. Incidence of the light from convex lens 55A is not carried out to a photo detector 71. An optical switch becomes off.
[0084] Drawing 22 is the sectional view showing other examples of an optical switching unit. The same sign is given to the same thing as what is shown in drawing 21, and duplication explanation is omitted.
[0085] In the optical switching unit 90, the auxiliary structure 31 is arranged under the silicon substrate 32. Convex lens 55A is being fixed to the condition of having done a handstand caudad by electrical-potential-difference impression of a between [movable electrode 34A and fixed electrode 46A], and the energization to the polyimide supporters 44. As for a photo detector 71, the location is controlled according to impression of the electrical potential difference between movable electrode 34B and fixed electrode 46B, and a halt.
[0086] The optical passage holes 32D and 32E which open hole 32A, exterior, and hole 32A and hole 32C for free passage are opened in the part which the light of a silicon substrate 32 should pass. Incidence of the light by which outgoing radiation was carried out is carried out to convex lens 55A through optical passage hole 32B from a light emitting device (illustration abbreviation). Incidence of the light condensed or collimated by convex lens 55A is carried out to a photo detector 71 through optical passage hole 32E. Optical switching is attained like the optical switching unit 80 shown in drawing 21 by what (the electrical potential difference impressed between movable electrode 34B and fixed electrode 46B is controlled) the posture of a photo detector 71 is controlled for.
[0087] It cannot be overemphasized making the functional device represented by a convex lens, a light emitting device, and the photo detector stand up perpendicularly on a silicon substrate 32, or not only making it do a handstand perpendicularly in the hole made in the silicon substrate 32 but that it is fixable with the posture which turned the include angle of arbitration. A functional device is also fixable with the posture which turned to the include angle of arbitration by adjusting the timing which passes a current to the magnitude or polish recon of the electrical potential difference impressed between a fixed electrode and a movable electrode. If the piezoresistive element is formed in the leg (the polish recon 54, polyimide 55, or PZT actuator 17), the include angle stored in the include angle of standing up of a functional device or the hole of a silicon substrate 32 based on the resistance value change outputted from a piezoresistive element is detectable. Based on the resistance value change of a piezoresistive element, the posture of a functional device is controllable. A piezoresistive element may be formed on a bar 35. Torsion of a bar 35 is detected and the include angle stored in the include angle of standing up of a functional device or the hole of a silicon substrate 32 is detected.

[Translation done.]

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3.In the drawings, any words are not translated.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing some optical substrates produced using polyimide.
[Drawing 2] (A), (B), (C), and (D) are the sectional views showing the process which produces the optical substrate shown in drawing 1 .
[Drawing 3] It is the sectional view showing the optical substrate of other structures produced using polyimide.
[Drawing 4] (A) The top view and (B) which show the structure of the optical substrate equipped with the ** PZT actuator It is a sectional view so at the IV-IV line of (A).
[Drawing 5] (A) The top view and (B) which show the structure which attached the supporter to the convex lens equipped with the ** PZT actuator (A) V-V It is a sectional view so at a line.
[Drawing 6] the top view showing the making process of (A1), (B1), and (C1) (D1) the convex lens shown in drawing 5 -- it is -- (A2) and (B-2) -- and (C2) (D2) -- respectively (A1) -- (B1) -- and (C1) (D1) VIA-VIA A line and VIB-VIB A line and VIC-VIC A line and VID-VID It is a sectional view so at a line.
[Drawing 7] (A1) and (B1) the top view showing the making process of the convex lens shown in drawing 5 -- it is -- and (A2) (B-2) -- respectively (A1) -- and (B1) VIIA-VIIA A line and VIIB-VIIB It is a sectional view so at a line.
[Drawing 8] (A) The top view of a lens array which becomes a convex lens with a ** PZT actuator from the thing of structure which attached the supporter, and (B) (A) VIII-VIII It is a sectional view so at a line.
[Drawing 9] It is the perspective view showing a minute spacial configuration object and the auxiliary structure used for the process which makes a functional device stand up.
[Drawing 10] X-X of drawing 9 It is a sectional view so at a line.
[Drawing 11] (A), (B), and (C) It is the sectional view showing the process which makes the functional device in a minute spacial configuration object stand up.
[Drawing 12] It is the perspective view showing a minute spacial configuration object with other configurations, and the auxiliary structure used for the process which makes a functional device stand up.
[Drawing 13] XIII-XIII of drawing 12 It is a sectional view so at a line.
[Drawing 14] It is the sectional view of the micro optical unit containing the convex lens with which the PZT actuator was formed.
[Drawing 15] the top view showing the making process of the micro optical unit containing (A1) and (B1) (C1) the convex lens with which the PZT actuator was formed -- it is -- (A2) and (B-2) -- and (C2) -- respectively (A1) -- and (B1) (C1) XVA-XVA A line and XVB-XVB A line and XVC-XVC It is a sectional view so at a line.
[Drawing 16] the top view showing the making process of the micro optical unit containing (A1), (B1), and (C1) the convex lens with which the PZT actuator was formed -- it is -- (A2) and (B-2) -- and (C2) -- respectively (A1) -- and (B1) (C1) XVIA-XVIA A line and XVIB-XBIB A line and XVIC-XVIC It is

a sectional view so at a line.
[Drawing 17] the top view showing the making process of the micro optical unit containing (A1) and (B1) (C1) the convex lens with which the PZT actuator was formed -- it is -- (A2) and (B-2) -- and (C2) -- respectively (A1) -- and (B1) (C1) XVIIA-XVIIA A line and XVIIB-XBIIB A line and XVIIC-XVIIC It is a sectional view so at a line.
[Drawing 18] (A1) is the top view showing the making process of the micro optical unit containing the convex lens with which the PZT actuator was formed, and (A2) is XVIII-XVIII of (A1). It is a sectional view so at a line.
[Drawing 19] It is the sectional view showing the making process of the micro optical unit containing the convex lens with which the PZT actuator was formed.
[Drawing 20] It is the sectional view showing the making process of the micro optical unit containing the convex lens with which the PZT actuator was formed.
[Drawing 21] It is the sectional view of the micro optical unit which constitutes a switching device.
[Drawing 22] It is the sectional view showing other examples of the micro optical unit which constitutes a switching device.
[Description of Notations]
10 10A Convex lens
11, 51, 53 SiO2 Sacrifice layer
12 12A Optical substrate
13 Lower Layer Metal Membrane
14 PZT Thin Film
15 The Upper Metal Membrane
30 Minute Spacial Configuration Object
31 Auxiliary Structure
32 Silicon Substrate
33 Frame Section
34 34A Movable electrode
35 Bar
41 Insulator Layer
42 External Connection Terminal
43 Leg
46 Fixed Electrode

[Translation done.]

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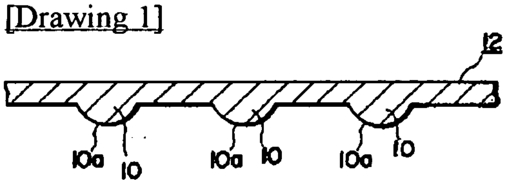
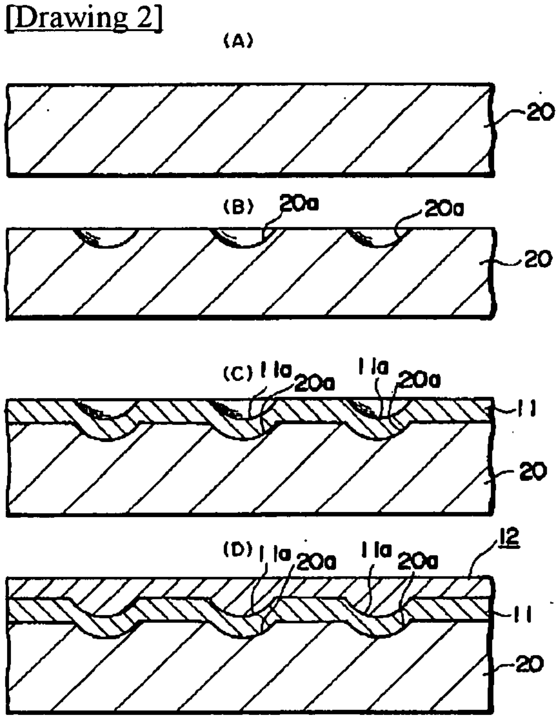
DRAWINGS

[Drawing 1]



[Drawing 2]



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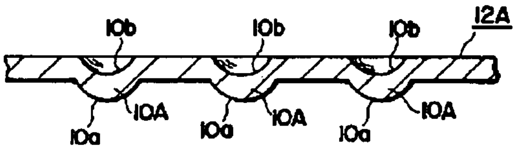

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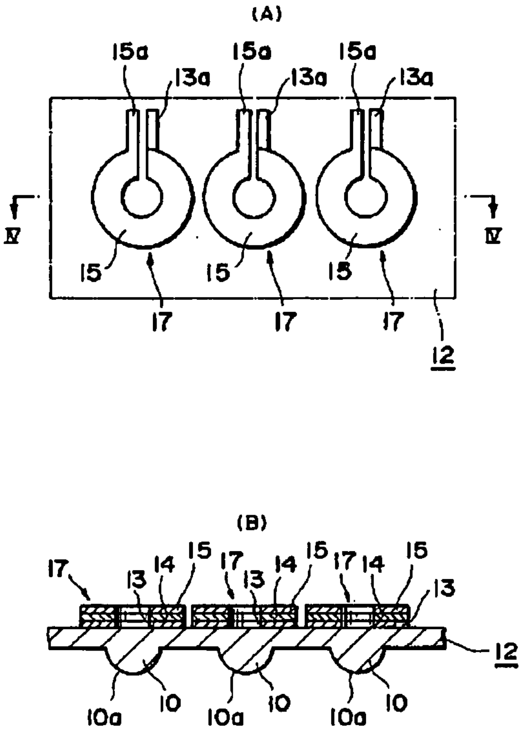

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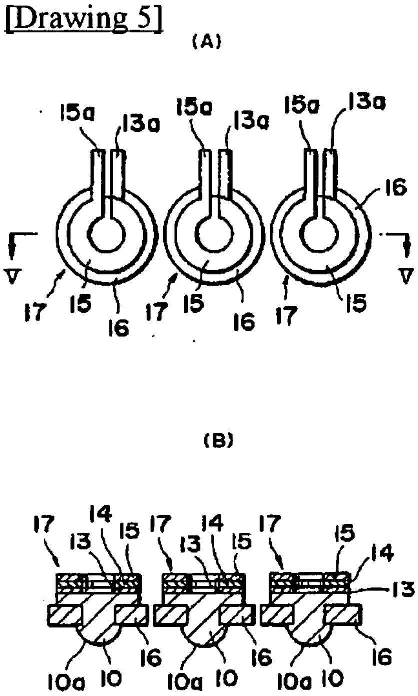

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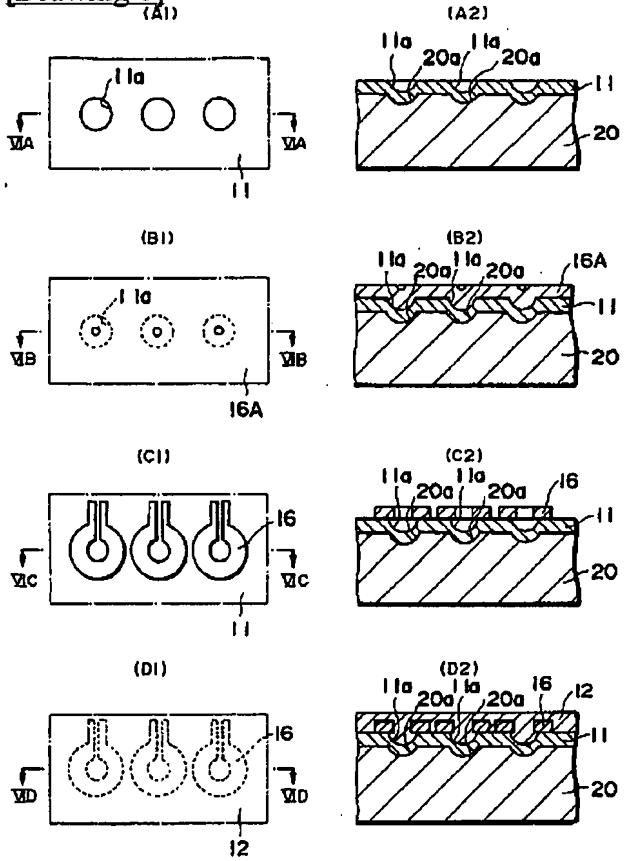

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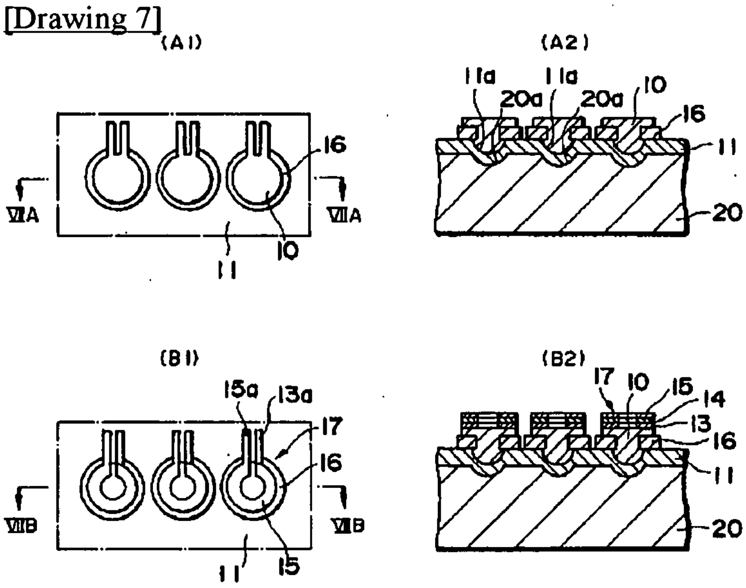
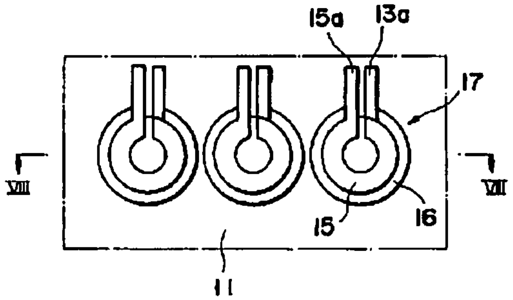
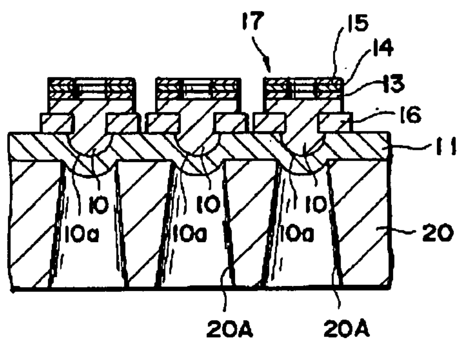


[Drawing 8]

(A)



(B)



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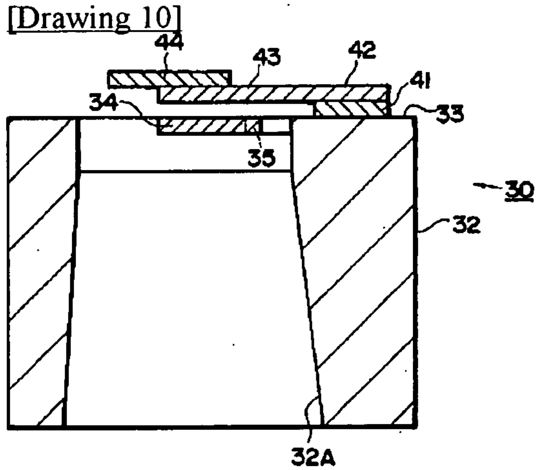
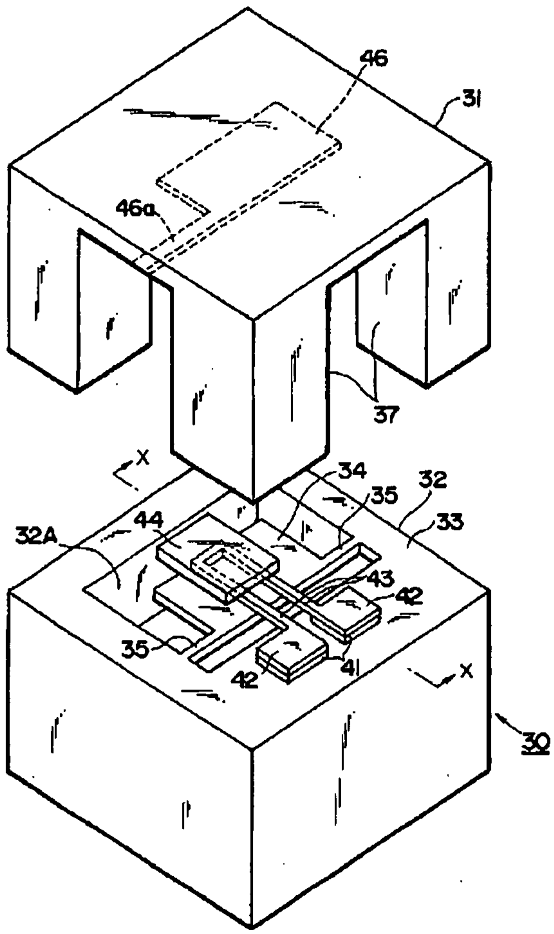


[Drawing 9]



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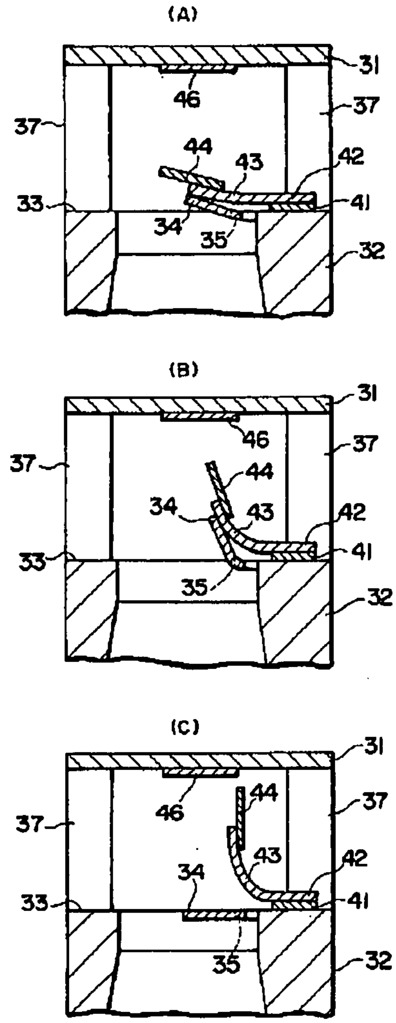
(A)
31
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(B)
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(C)
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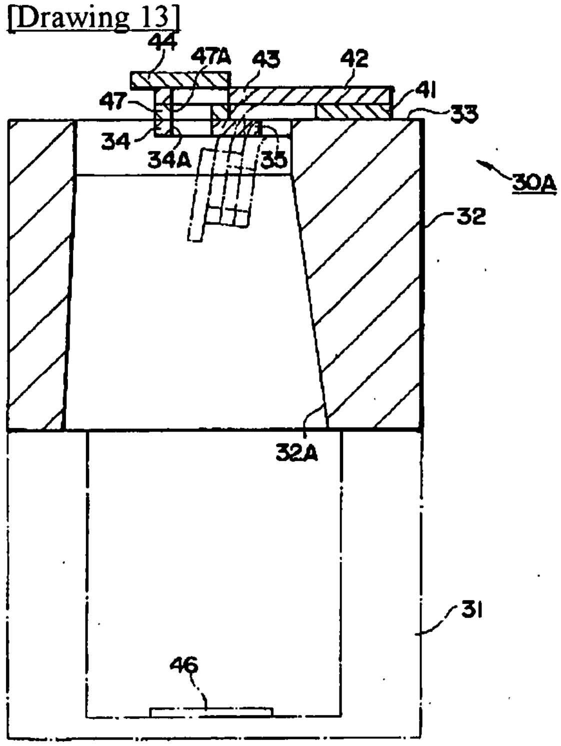
[Drawing 13]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34A
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32A
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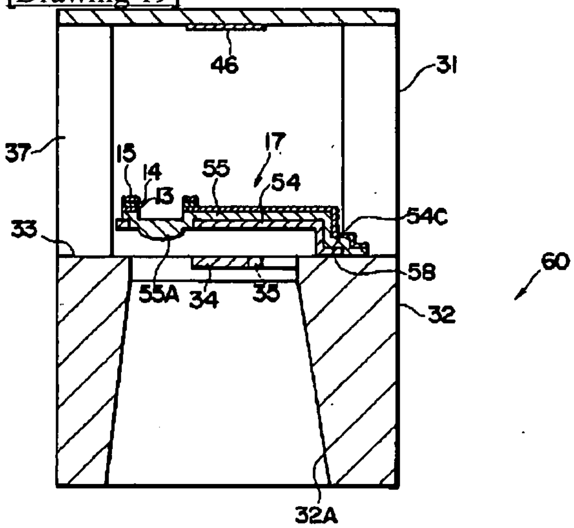
[Drawing 19]



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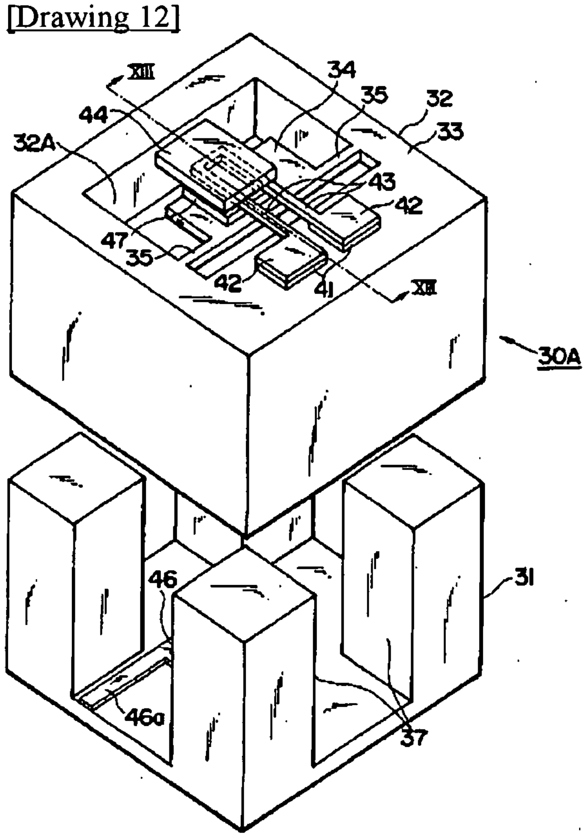

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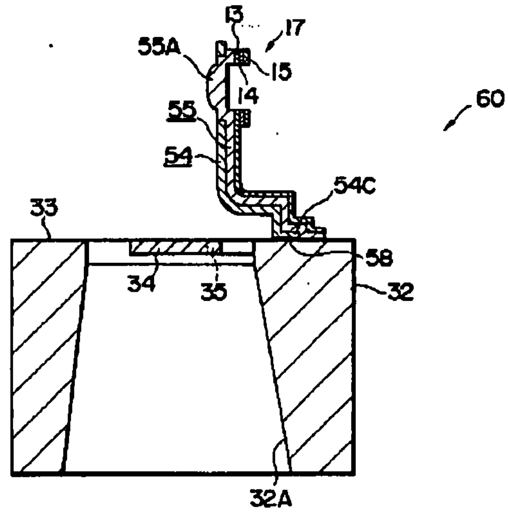

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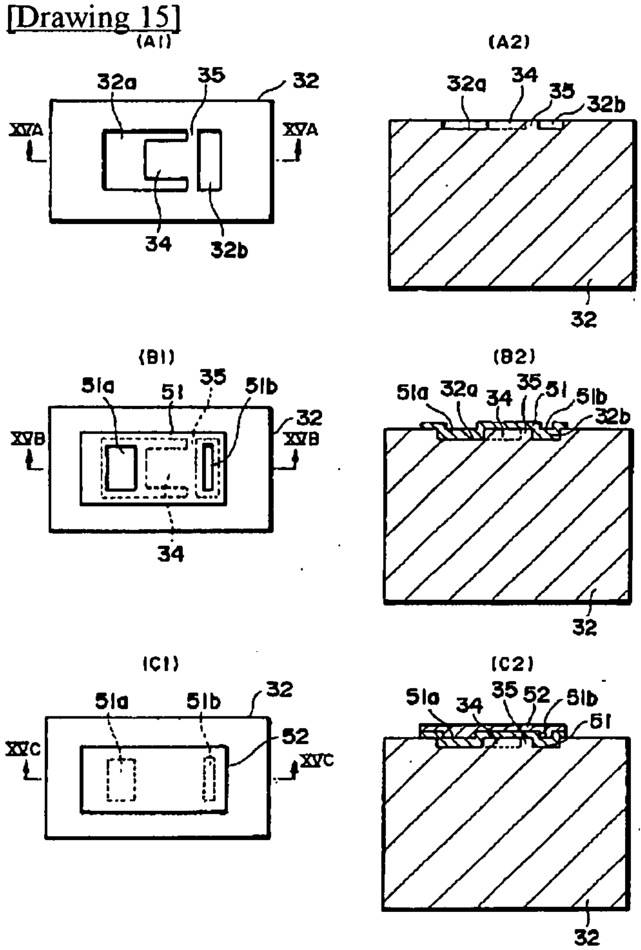

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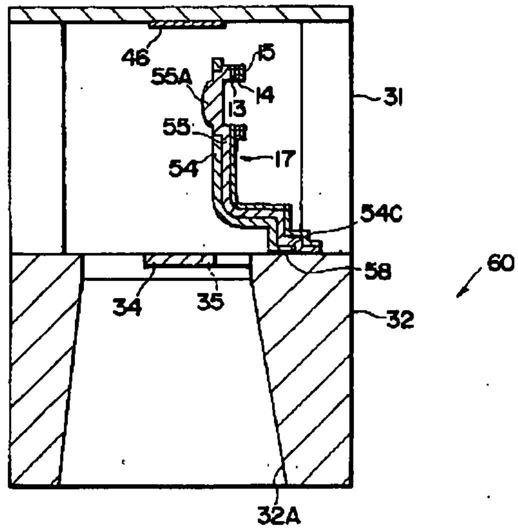

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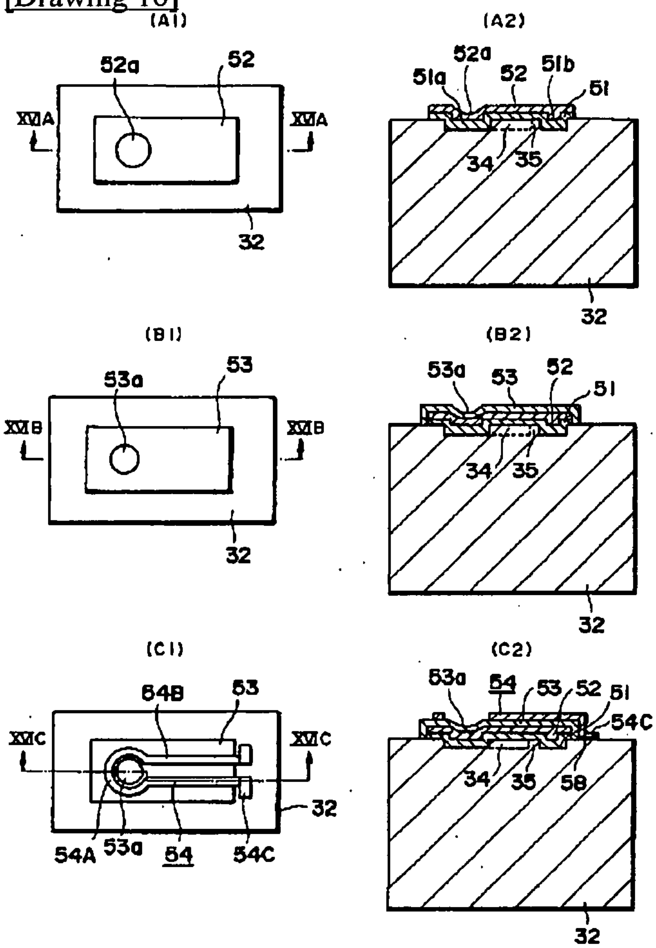

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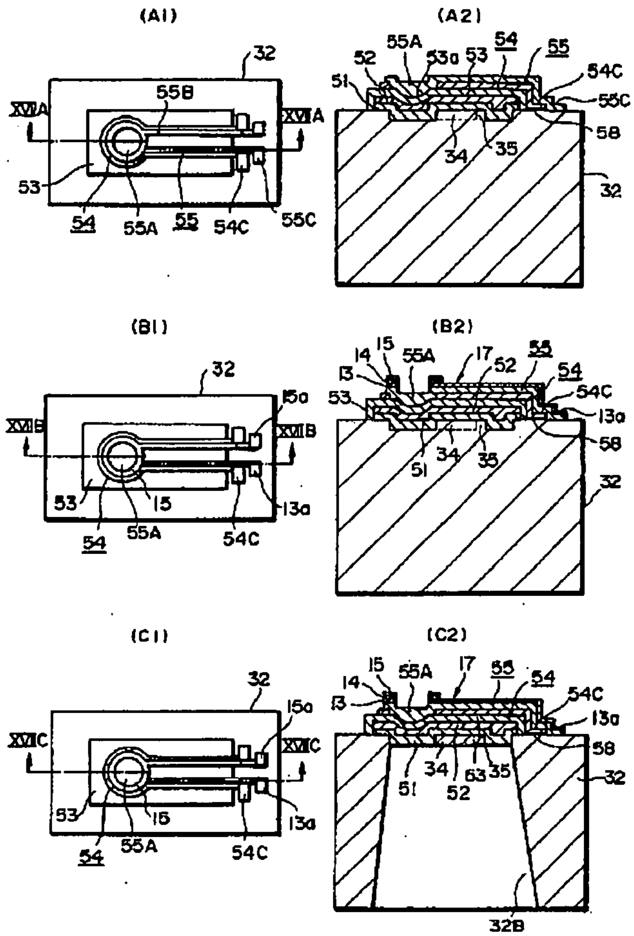
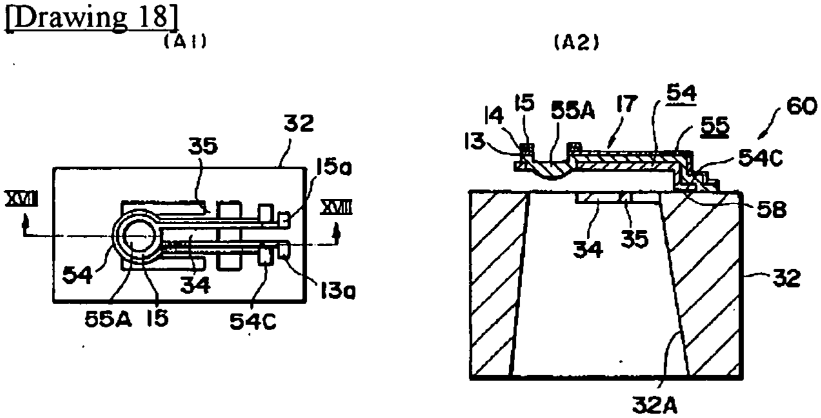
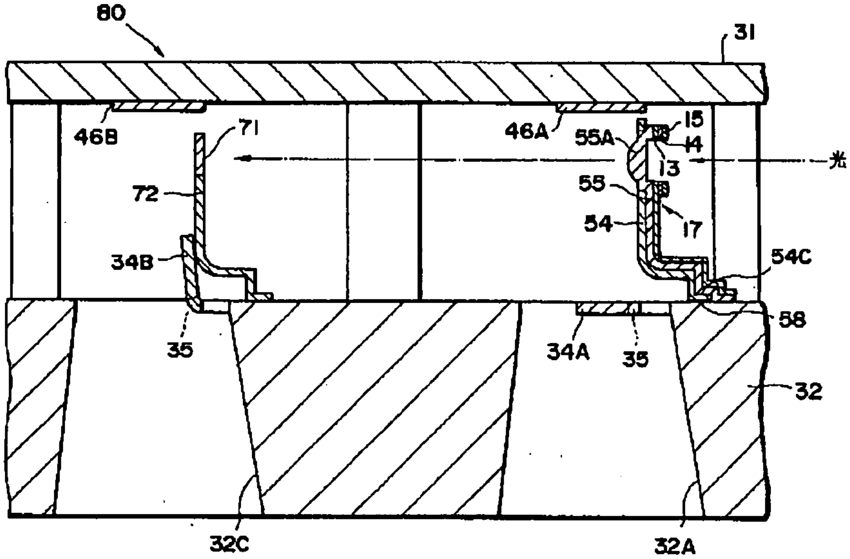


[Drawing 18]



[Drawing 21]



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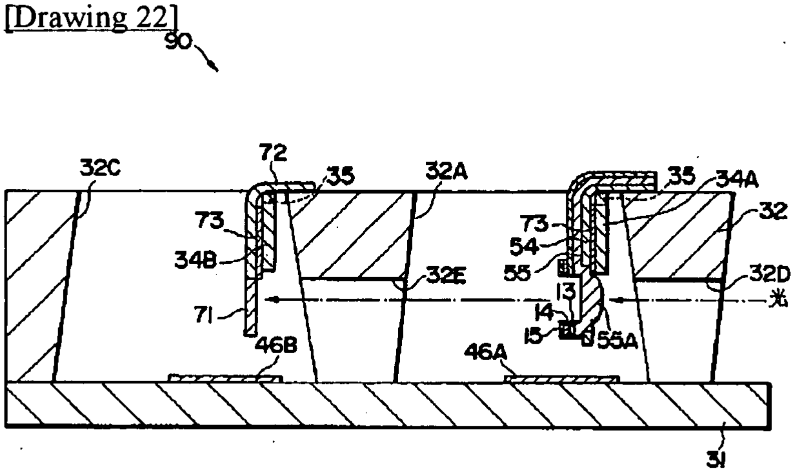

[Translation done.]